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AIRFLOW DISTRIBUTION SYSTEMS FOR FOOD PROCESSORS

Field of the Invention

The present invention relates to forced airflow systems for food treatment facilities such as vertical rise dryers, smokers, curing chambers, ovens or warmers, coolers, and/or freezers.

Background of the Invention

Conventionally, several different food treatment system configurations have been used to smoke, cure, dry, cook, cool, or freeze food products such as meat products so as to increase production capacity while attempting to limit the floor space required for carrying out same. In so doing, vertical rise systems have been used with spiral conveyors to move food vertically through the oven while exposing the food to certain processing conditions as it moves from top to bottom or bottom to top. Other systems employ tunnel or linear floor mounted systems that direct food through on trolleys or the like.

Examples of vertical systems include the Northfield LST (Large Spiral Technology) freezer available from Frigoscandia Equipment (fmcfoodtech.com)is a high capacity non-self stacking spiral freezer that employs spiral conveyors with belts available in different widths. Ryson International Inc. of Newport News, Virginia, provides spiral conveyors that are purported to feature a small footprint and space savings over other brands with load capacities of up to 200 fpm. Another example is the TURBO-Dryer® from Wyssmont (wyssmont.com). The TURBO-Dryer® uses a stack of slowly rotating circular trays. In operation, food is fed onto the top tray and, after one revolution, is wiped onto the next lower tray where the operation is repeated. The trays are enclosed in a vertical enclosure that circulates heated air or gas about the food on the trays. Each level in the enclosure may be held at a uniform

temperature or the enclosure may be configured with zoned temperature regions having different temperatures. Yet another example is found in U.S. Patent No. 5,942,265 that describes conveying pepperoni meat to a conventional spiral dryer that includes a number of tiers (typically about 38-42) according to the initial moisture level, the desired final moisture level, the relative humidity of the air, the total amount of water to be removed, the temperature, and the conveyor speed.

An example of a tunnel-like system, available from ALKAR located in Lodi, Wisconsin, employs a plurality of serially connected in-line rooms or chambers with sidewalls and front and rear doors on opposing sides of the rooms that cooperably open and close to hold the food enclosed within each room for predetermined intervals of time as the food progresses forward on the trolleys through the series of rooms forming the tunnel. The walls may include a series of downwardly extending baffles that are aligned with baffles on the opposite wall.

The food is positioned on a trolley that is automatically moved serially horizontally forward through the tunnel and stopped in each chamber for a period of time so that the food on the trolley is exposed to the environmental conditions in the enclosed chamber. The trolley may include multiple batches, trays, or tiers of stacked food items. In operation, the trolley is suspended from rails and enters the open doors of one chamber and the front and rear doors of the chamber close with the trolley stopped therein, thereby defining a closed chamber. One or more trolleys rests in the closed chamber for a period of time during which the chamber is brought to its desired temperature and food can be exposed to heated air-flow. Subsequently, doors on the opposing side of the chamber open, and the trolley then re-initiates movement to pass through the open doorway and enter the next in the serial line of chambers or rooms. Each chamber or room may generate a different environmental condition. The trolley may be connected to a series of trolleys that move in unison through the various chambers.

When processing food through the various systems, the distribution of air or airflow about the food may influence the manner in which the food is cooked, cooled, or otherwise thermally and/or environmentally processed. Uneven distribution patterns may yield a non-uniformly processed product batch. This can be particularly problematic in large capacity continuous process ovens. Other airflow or air

distribution patterns may increase the time it takes to reach the desired environmental condition or temperature and may be inefficient in its use of energy.

For example, in general, in the tunnel system, heated air may be directed to flow down from nozzles positioned on the ceiling, discharged at various vertical heights through baffles along one sidewall, and then collected to travel back up to exit in the opposing sidewall of the chamber or at a centrally located exit-air return, that may also be located about the top portion of the chamber. This airflow pattern forces air down about the food on the static trolley, the air rebounds off the walls and floor (and/or trolleys, trays, and screens) and travels back up through the food on the trolley to exit in the air-return. The airflow may be characterized as substantially laminar, potentially inhibiting uniform heat transfer and/or air distribution about the product on the trolley or trolleys. Unfortunately, fresh air may be unevenly distributed in the chamber; the product in the chamber may be non-uniformly exposed potentially leaving dead-spots and/or irregular degrees of exposure to heat and or moisture. This may yield a thermally inconsistent product at various locations thereof so that portions of the product may be overdone, underdone and/or inconsistently processed.

For continuously or substantially continuously moving product lines that move during the thermal treatment itself (such as those employing moving or conveying floors), uniform air distribution may also be problematic in that the moving floors may create physical or air wall blockage or turbulence that can also inhibit the uniform exposure or create undesirable temperature gradients in the system (such as an oven). For example, in round and/or vertical stacked tier ovens or systems that employ substantially circularly configured moving floors, a centrifugal force may be generated that may undesirably force the heated or desired environmental air to the outermost wall of the oven causing a potential large and inefficient temperature gradient at certain zones or regions in one or more tiers or levels of the oven.

In view of the foregoing, there remains a need to provide alternative airflow distribution systems for food processors.

Summary of the Invention

The present invention provides forced fluid flow distribution systems that can direct exogenously introduced fluid (typically primarily a gas or gas mixture such as air) to flow in a flow path that directs the fluid across food held on a food track having

an associated width. As such, the flow includes a lateral directional component and may also include a vertical component.

Certain embodiments are directed to operations for treating food traveling through a food processor. Such embodiments include: (a) moving at least one food item over a predetermined travel path in a food processor having a food travel pathway comprising a moving floor and upwardly extending first and second sidewalls located on opposing sides thereof, the travel pathway having corresponding first and second side portions; (b) introducing exogenous fluid into the food processor from a plurality of inlet ports positioned proximate the first sidewall during the moving step to thereby thermally treat the food; (c) exhausting the fluid from the food processor from a plurality of exhaust ports positioned proximate the second sidewall; and (d) directing the exogenous fluid from the introducing step to travel from the first side portion to the second side portion over the food held on the food travel pathway.

The treatment can comprise a thermal treatment (heating and/or cooling), smoking, chemical, radiation, light, and the like. In certain particular embodiments, the food processor includes a plurality of vertically stacked tiers each having a portion of the food travel path thereon, the vertically stacked tiers being longitudinally spaced apart a desired distance. In such embodiments, moving the food item can be provided by (substantially continuously) advancing the food to travel successively over a plurality of the different tiers.

Other embodiments are directed at food processing apparatus with forced fluid distribution systems. The apparatus includes: (a) a housing defining an enclosure and having a food inlet and a food outlet; (b) a plurality of stacked tiers residing in the housing, one or more tiers defining a treatment zone within the food processing apparatus, each of the tiers comprising a moving floor that moves the food along its desired travel path over a primary surface of a respective tier; and (c) a forced fluid distribution system in fluid communication with the stacked tiers. The forced fluid distribution system includes: (a) a first plurality of inlet ports positioned on a first side of the food travel path proximate each tier; (b) a second plurality of exhaust ports positioned on a second side of the food travel path across from the plurality of inlet ports proximate each tier; and (c) an exogenous supply of treated fluid operably associated with the inlet ports. In operation, the treated fluid (which can comprise

thermally treated air or gas) flows over the food, in selected tiers, as the food is substantially moving through a treatment zone.

The food can be positioned on a floor that includes one or a plurality of side-by-side lanes. The floor can be configured to substantially continue move the food along its travel path during the desired treatment(s) in the processor.

In particular embodiments, the second plurality of exhaust ports are fewer in number than the first plurality of inlet ports and the exhaust ports are configured so that they have a cumulative cross-sectional area that is greater than that of the cumulative cross-sectional area of the inlet ports. In other embodiments, the forced distribution system further includes a pressure relief valve that is configured to release fluid from the food processor upon the detection of elevated pressure levels. The exhaust ports may be also be configured so that they present a cumulative cross-sectional area that is less than that of the cumulative cross-sectional area of the inlet ports.

In particular embodiments, treated gas or air is introduced into an enclosure that has an outer perimeter wall and an inner perimeter wall. The gas/air is introduced into the enclosure from a common wall (either the outer or the inner) and forced to travel across the width of the enclosure to exit from the opposing common wall (*i.e.*, either the inner or the outer, respectively) so that the air travels across the distance of the enclosure between the opposing walls. Ducts may be used so that the physical intake and exit primary channels are disposed together about a single wall or side to reduce the amount of floor space needed to support the air distribution structure. The gas/air may be untreated or treated (thermally, chemically, and the like).

In other embodiments, the present invention provides a forced distribution configuration that is able to provide a predetermined thermal gradient that is substantially constant across a lane or lanes holding food product and/or that inhibits an undue gradient at the edges of one side the enclosure, that may be particularly suitable for vertically stacked tiers having multiple zones or tiers that are held within the enclosure.

In certain embodiments, the enclosure encases a plurality of stacked tiers that each defines at least a portion of a product flow path. At each tier, the product travel path can include a moving floor that is defined by one or more conveyors. The fluid flow system can include a plurality of spaced apart inlet ports that are positioned on a

first side of the product travel path and a plurality of spaced apart outlet ports that are positioned on a second opposing side of the product travel path. The distributed fluid can be directed to move over the product on the floor of the travel path, even as the food is advanced during the treatment processing potentially introducing complex air-patterns generated by the moving floors.

In certain embodiments, the fluid distribution system distributes air and may be configured so that the number of inlet ports is greater than or equal to the number of outlet ports. The cumulative cross-sectional area of the inlet ports may be configured in size and/or shape so as to be substantially equal to and/or less than the cumulative cross-sectional area of the outlet ports thereby providing an equilibrated or decreased internal pressure that may promote a vacuum. In other embodiments, the cumulative cross-sectional area of the inlet ports can be greater than that of the outlet ports and the outlet ports can be operably associated with an over pressure relief valve that periodically discharges pressure when a certain level is detected or that substantially continuously discharges air to maintain pressure at a desired level.

In certain embodiments, cooperating side-by-side conveyors on each tier can be configured (such as pairs or more of continuously circulating conveyor belts) so that the food travels first on a first conveyor belt and then moves to an adjacent belt as the food travels greater than one revolution (and typically at least about 1.25-2 revolutions) about a majority of the tiers or levels. In other embodiments, the same conveyor can be used to provide the more than one revolution in each tier (diverting the food into different tracks within the same conveyor) or looping the conveyor to define a greater than one revolution travel path. In certain embodiments, the food item can be physically diverted, dropped, or elevated to a next adjacent underlying or overlying tier for further processing. The food item can be a meat product, and in particular embodiments, may be an elongated meat product (such as a substantially continuous length of linked, crimped, twisted or strand of food product). In other embodiments, the product can be a discrete length of meat product.

Certain embodiments of the invention include methods and systems for directing food through a multi-tier food processor that may be configured as an oven, an incubator, a chiller, a cooler, a dryer or combinations thereof. At least one food item is conveyed over a predetermined travel path in a food processor having a plurality of overlying or underlying tiers which are longitudinally spaced such that the

at least one food item travels greater than one revolution in a first tier before it moves to the next tier (which may be aligned or misaligned with the adjacent tier(s) as desired). As the food travels in the travel path thermally treated gas (or gas mixtures that may include air) is forced over the food to treat the food in a predetermined manner. The gas may be heated, cooled, smoked, and/or moisturized or otherwise treated.

In certain embodiments, ducts, tubing, or pipes can be used to position the desired inlet and/or outlet ports at various vertical spaced locations in the enclosure or processing system.

Still other embodiments are directed to nested food processing apparatus. As such, the apparatus includes: (a) an outer processor having spaced apart inner and outer walls defining an enclosure therebetween and a food inlet and food outlet; and (b) an inner processor defining an enclosure having associated upwardly extending sidewalls and a food inlet and a food outlet, wherein the outer processor is configured to receive and surround the inner processor. Each of the inner and outer processors are configured to provide separately regulated operating environments. The outer and inner processors may include: (a) a plurality of vertically stacked tiers held within the enclosure; (b) at least one conveyor operably associated with each tier, the at least one conveyor being configured to move a food item about the tier such that the food item travels greater than one revolution in each tier; (c) transfer means operably associated with the tiers for directing the food to travel to the next selected tier; and (d) a gas flow distribution system. The gas distribution system may include: (a) an exogenous supply of gas (which may be thermally treated and/or comprise particulate matter in particular embodiments); (b) a first plurality of spaced apart inlet ports positioned in the processing apparatus proximate to each tier about a selected one of the inner or outer walls in fluid communication with the exogenous supply of gas; (c) a second plurality of spaced apart exhaust ports positioned in the processing apparatus proximate to each tier about a different one of the walls selected to locate the inlet ports, wherein the second plurality is less than the first plurality to thereby provide fewer exhaust ports. The gas distribution system may be configured to continuously distribute gas while food is moving through each tier.

Each of the inner and outer processors can comprise portions that are ovens and/or can be configured to provide separate temperature regulated (and/or moisture

or humidity, air velocity, cooling, heating, sprinkling, gas, and the like) spaces. The outer and inner ovens can include a plurality of stacked tiers held within the respective enclosures and one conveyor and/or a plurality of cooperating conveyors operably associated with each tier. The conveyor and/or cooperating conveyors can be configured to move the at least one food item serially over a major portion of the travel path to thereby provide more than one revolution in each tier. The processors can also include transfer means for directing the food to travel to the next selected (typically the adjacent) tier. The gas flow system may be configured to distribute thermally treated air such that air is forced to travel over the primary surfaces of the conveyors so as to reduce the thermal gradient thereacross, provide a suitable air mass mixture, and/or reduce undesired thermal clustering in the apparatus (hot or cold spots) to provide a processor with increased thermal efficiency.

Still other embodiments are directed to food processing systems having at least one food processing chamber with a plurality of stacked tiers for treating food. The systems include: (a) means for moving food through a food processing chamber having a plurality of stacked tiers, as the food is held on a food support surface; (b) means for directing exogenous gas to flow across food held on the food support surface held inside the food processing chamber while the food is moved in the chamber; and (c) means for exhausting gas comprising the exogenous air from the chamber while the food is moved in the chamber.

The foregoing and other objects and aspects of the present invention are explained in detail in the specification set forth below.

Brief Description of the Drawings

Figure 1 is a schematic diagram of a multi-tier food processor according to embodiments of the present invention.

Figure 2 is a perspective view of a stacked multi-tier processor according to embodiments of the present invention.

Figure 3 is a schematic top view of a portion of a travel pathway or track (that may be defined by a moving floor where food product is located during operation) in a tier of a food processor showing the opposing sidewalls and the travel track positioned therebetween according to embodiments of the present invention.

Figure 4A illustrates the same view of the portion of the food processor shown in **Figure 3** with exemplary inlet ports disposed on one side of the track (shown as a greater number of the smaller sized ports) and exemplary exhaust ports disposed on the opposing side of the track (shown as the larger size ports in lesser numbers relative to the inlet ports) according to embodiments of the present invention.

Figure 4B illustrates a side view of a portion of the food processor illustrating that portion shown in **Figure 4A**, with the intake portion is located on a first, left-hand side of the chamber and the exhaust located on the opposing, right-hand side of the chamber.

Figure 5 is a cutaway top view of a tier of a food processor according to embodiments of the present invention.

Figure 6A illustrates the view shown in **Figure 5** with an exemplary forced gas distribution pattern according to embodiments of the present invention.

Figure 6B illustrates the view shown in **Figure 5** with an alternate exemplary gas distribution pattern according to embodiments of the present invention.

Figure 7 is a cutaway top view of a tier of an alternate embodiment of a food processor with a nested configuration according to the present invention.

Figure 8A is a schematic perspective view of a multiple vertically stacked tier configuration with an exemplary forced gas and/or air distribution pattern according to embodiments of the present invention.

Figure 8B is a schematic perspective view of a multiple vertically stacked tier configuration with an alternate exemplary forced gas and/or air distribution pattern according to embodiments of the present invention.

Figure 9A is a side sectional view taken along **lines 9A-9A** drawn in **Figures 8A, 8B** illustrating forced gas flow over multiple lanes of food product held on a multi-lane travel track configuration according to embodiments of the present invention (the arrows corresponding to the configuration shown in **Figure 8A**).

Figure 9B is a side sectional view of an alternate embodiment of a multi-lane travel track according to the present invention.

Figure 10 is a partial cutaway view of a vertically oriented multiple-tier configuration product travel pathway with each tier having a different associated

exemplary manifold or duct work arrangement for providing the desired forced gas/air flow pattern(s) according to embodiments of the present invention.

Figure 11A is a top view of a portion of a food travel pathway similar to that shown in **Figure 1**, illustrating a system employing primary ducts located on a common region of the food processor unit and intake and outlet/exhaust ports or openings still positioned across from each other to provide forced gas/air distribution systems according to embodiments of the present invention.

Figure 11B is a side view of the configuration shown in **Figure 11A** according to embodiments of the present invention.

Figures 12A-12D illustrate aligned and offset arrangements of inlet and outlet/exhaust ports according to embodiments of the present invention.

Figures 13A-13D illustrate examples of secondary ducts to distribute the desired gas/airflow distribution that are in fluid communication with a main duct that can be positioned on a common region or on opposing sides of the product and/or of the enclosure according to embodiments of the present invention.

Figure 14A is a top schematic view of a tier of a food processor that illustrates that the tier may be segmented and/or may position a reduced number of inlet and outlet ports on opposite sides of the track relative to the major portion of the respective inlet and outlet ports according to embodiments of the present invention.

Figure 14B is a perspective view of a portion of the segmented region of the tier shown in **Figure 14A**.

Figure 15 is a top schematic view of an alternate arrangement of tracks and inlet and outlet ports that may promote cross-flow of gas according to embodiments of the present invention.

Description of Embodiments of the Invention

The present invention will now be described more fully hereinafter with reference to the accompanying figures, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Like numbers refer to like elements throughout. In the figures, certain layers, components or features may be exaggerated for clarity.

Generally described, the present invention is directed to food processor systems that are particularly suitable for large-scale mass production of food items. The food processor system can be configured as a vertical rise system and can include different zones exposed to different processing and/or food treatment conditions, such as one or more of a dryer, a heater, an incubator, an oven, a curing or smoking source, a cooler, chiller, refrigerator or freezer, a flavoring and/or chemical or ingredient additive or preservative unit, and the like. The system can employ fluids such as gases and gas mixtures that provide a desired treatment or environment within one or more regions in the processor system. The fluid can include one or more gases as its major and/or primary constituent(s). As such, the fluid can be formulated to comprise one or more of a gas, a gas and liquid, and/or gas, with liquid and/or particulate matter to perform and/or assist in the treatment carried out on the food. For example, at desired zones or at all zones, the system may use ambient and/or thermally treated air (either heated and/or cooled, as desired). Examples of other suitable gases include nitrogen, oxygen, and the like. The liquid may be aqueous based (such as brine), or other suitable food compatible substance. Each zone may include ceilings or floors to help maintain its desired environmental condition (which may open in a cooperating manner to exchange food therebetween as desired). Portions of zones and/or tiers may also be segmented and separated from the remainder of the same zone as will be discussed further below with respect to **Figures 14A** and **14B**.

In certain embodiments, each or selected ones of tiers can include a food travel pathway defined by a moving floor including one or more conveyors. The food transport system may be configured to substantially continuously propel the food along its predetermined travel path about each tier so that the food travels while being thermally treated. In other embodiments, the food may be semi-continuously moved along its travel path (stopping at desired intervals therealong), but, typically, the product is continuously moved along its travel path during a major portion of the thermal processing (*i.e.*, while thermally treated air is forced over the product).

The food processor can be configured to process solid or semi-solid food items or liquid items in containers or casings. Examples of food items include, but are not limited to, baked goods, candies, bakery (including dough and/or bread) products, dairy products, vegetables, snack or dessert items, and meat products. In certain embodiments, the food processing system and/or related devices may be particularly

suitable to process discrete low profile items (substantially planar or flat objects), as well as elongated food items such as, but not limited to, elastic or partially elastic food items such as cheese (like mozzarella strands), dough (for incubation), meat sticks or strands, and the like.

In certain embodiments, the systems are configured to process discrete portions of a meat product and/or a length of an elongated product held in a casing. The casing can be any suitable casing (edible or inedible) such as a collagen casing. The elongated product can be an elongated meat product. Exemplary products include, but are not limited to, strands of meat such as pepperoni or beef, a processed meat product such as a pepperoni or beef stick, sausage, hotdog, or the like.

The elongated meat product can be configured as a contiguous or continuous length of product. The length may be selected so as to cover one or a plurality of lanes, tracks or perimeter paths over at least one tier or level. In certain embodiments, the length of product is contiguous or continuous so as to be able to extend over at least one revolution in a lane in a desired travel path. In certain embodiments, the elongated meat product has a length of at least about 20-25 feet, and may be, in particular embodiment at least about 50 feet. In other embodiments, the elongated meat product can have a length of between about 50-85 feet or more.

The processing system can be configured to substantially continuously move or automatically semi-continuously convey other items through a processing facility where enhanced capacity is desired. For example, a product processing system for medical products, pharmaceuticals where sterilization is desired or for implements, surgical tools or other items desiring sterilization, or manufacturing facilities for products undergoing curing, coating, brazing, tempering, sintering, or other processing condition. *See* co-pending U.S. Patent Application Serial No. 09/888,925, filed June 25, 2001 for descriptions of exemplary ovens and transport systems, the contents of which are hereby incorporated by reference as if recited in full herein. *See also* co-pending U.S. Provisional Application Serial No. XXX filed February 4, 2002, identified by Attorney Docket No. 9281-3PR for description of exemplary food alignment and guiding mechanisms, the contents of which are also hereby incorporated by reference as if recited in full herein. *See also*, U.S. Patent No. 4,582,047 and RE35,259, U.S. Patent No. 5,942,265, U.S. Patent No. 5,078,120, and U.S. Patent No. 4,079,666 for descriptions of exemplary processing conditions for

food and conveyor means, the contents of which are hereby incorporated by reference as if recited in full herein.

In certain particular embodiments, the present invention is used to move a strand, strands or lengths of elongated meat product. For example, strands of meat such as pepperoni or beef, a processed meat product such as a pepperoni or beef stick, sausage, or hotdog. The elongated food item may be elastic (at least in tension) so as to allow stretching without unduly altering or deforming its desired shape during processing. The elongated food item may be held in a natural or synthetic casing. In operation, the elongated meat product may have an exterior surface that exhibits increased friction relative to a finished, cured, or dried configuration. For example, a collagen casing can be described as having a relatively gelatinous sticky residue prior to its finished state that can cause the food to attempt to stick to a floor or support surface during transport and may make it difficult to route or guide this type of product in an automated relatively fast speed transport arrangement, particularly where non-linear or selectably changeable travel paths are desired.

Turning to **Figure 1**, a vertical rise food processor **10** is shown with a plurality of longitudinally spaced tiers **11, 12, 13, 14** configured to provide a desired vertical height(s) within the processor and residence time in each tier (or, combined, the residence time in the food processor). Each tier **11, 12, 13, 14** may be configured to cooperate and form a portion of a cumulative food travel path, or to operate alone or with selective ones of the other tiers. The number of tiers employed can vary depending on the application and typically will include at least three and up to 60 or more. The food processor **10** includes an enclosure with two upwardly extending opposing sidewalls **$10w_1$**, **$10w_2$**, a ceiling **10c** and floor **10f**. The enclosure is configured to provide an environmentally protected processing space.

As used herein, the term "vertically stacked" means that the tiers, shown as elements **11-14** in **Figure 1,** are positioned as vertically or longitudinally spaced apart tiers, each tier (or a plurality of tiers) extending within a certain vertical region or zone of the processor. The vertically stacked tiers may be substantially vertically aligned (such as in a single column) as shown. Alternatively, one or more tier may be laterally offset relative to the other tiers. Each zone may have an independently controllable environment. The stacked tiers **11-14** may be arranged with substantially equal distances between adjacent ones of the tiers or with closer or further distances

between adjacent tiers and/or combinations of same. The tiers may have planar floors or inclined (up or down floors) (not shown). Thus, although shown in **Figure 1** as a substantially planar tier surface, the travel path may be curvilinear or move vertically up and down a desired distance as it moves over each level in the tier. In certain embodiments, each tier defines a portion of the travel path in the processor **10** for the food item and can be any desired shape such as, but not limited to, circular, oval, rectangular, hourglass, or figure 8. The tiers **11-14** can be arranged such that each tier overlies or underlies the next adjacent tier in the travel path. The stacked tiers **11-14** may be offset or aligned as noted above.

The travel path is the path that the food travels within a particular tier as it travels in the food processor from the inlet to the outlet. In certain embodiments, each tier or zone (one or a plurality of selected tiers) as well as portions of each tier can be configured to have an individually controlled environment to provide the desired operating environments (to provide the desired physical treatments such as moisture or humidity (sprinkling), air velocity, gas exposure, temperature and the like).

As noted above, the food processor **10** can be arranged such that selected or each tier is aligned or offset relative to the others, as desired. The height and diameter or width and length of the tiers within the processor **10** can vary, and typically is sized corresponding to the desired residence time in a food processor unit. **Figure 2** illustrates one embodiment of tiers **11, 12, 13, 14** where the tiers are substantially circular, that is, co-axially arranged with circular and substantially planar travel paths in each tier. However, other shapes of tiers and shapes and orientations of respective travel paths can also be employed. In the embodiment shown in **Figure 2**, the opposing sidewalls **$10w_1$, $10w_2$** (shown in broken line) are defined by an outer perimeter wall **$10p_1$** and an inner perimeter wall **$10p_2$**. Although the inner and outer walls **$10p_1$, $10p_2$** are shown as cylindrical walls, other configurations may also be employed. The food processor may include a food inlet port **10i** that may be located at a top portion of the unit and a food outlet **10e** that may be located a vertical distance downwardly therefrom (allowing the food to progress downwardly as it moves through the different treatment zones). In other embodiments, the inlet **10i** can be at the bottom portion of the unit (not shown) and the food progress upwardly through the processor **10**. In other embodiments, intermediate entry and exit locations

can also be used (not shown). Furthermore, multiple inlets and exits may also be provided.

Figure 2 also illustrates that in certain embodiments, each tier can have at least two serially arranged perimeter travel paths **59**, **60** thereon. As shown, the two perimeter travel paths can be descried as an innermost travel path **59** and outermost perimeter travel path **60**. Of course, additional intermediate perimeter travel paths can also be disposed on one or more tier. The tiers **11-14** can be arranged so that, in operation, the food travels greater than one revolution on a single tier before the food item(s) travel to the next tier. In certain embodiments, the system is configured such that the food travels at least about 1.1-1.25, and typically about two or more revolutions, on a single tier (and in certain embodiments greater than one revolution on a plurality or all of the tiers within the processor).

It is also noted that in various figures (*i.e.*, **Figure 1**, **Figures 9A**, **12**, and **13**) the track **25** is illustrated as having a plurality of side-by-side channels (each with sidewalls). However, the track **25** may be otherwise configured; for example, but not limited thereto, the track **25** may include a single lane or a plurality of lanes, with the lanes not requiring sidewall guides therebetween, or a combination of lanes with and without the sidewalls.

In certain embodiments, the system can be configured such that the food moves more than one revolution on a single conveyor (*i.e.*, the conveyor may be looped or have multiple tracks thereon so as to define more than one perimeter travel path on a particular tier) before moving to a second conveyor or the next tier. In other embodiments, a plurality of cooperating conveyors are used on each tier to define the perimeter paths, as will be discussed further below. Combinations of each of these conveyor configurations are also contemplated by certain embodiments of the present invention.

As shown in **Figure 2**, the food is introduced at inlet **10e** and is directed to move (or drop) down to a primary upper surface of the tier **11** to travel clockwise a first revolution about a food travel path **25** that can include a plurality of side-by-side lanes. In the embodiment shown, the travel path **25** includes a first perimeter path **59** and a second perimeter path **60**. The food travels along the first perimeter path **59** until it reaches a transition or junction zone **50z** where the food physically moves or transitions a lateral distance over to travel a second revolution (or portion thereof) on

the second perimeter travel path **60**. As such, the food item travels greater than one revolution on the first tier, and typically, at least about 1.1-1.25, and in certain embodiments, at least about 1.5 to about two or more revolutions, on two or more perimeter paths (shown as only two in **Figure 2**), before it is directed to the next tier **12**.

As is also shown in **Figure 2**, in certain embodiments, after the food travels to approach the end of the second revolution, it approaches the transition zone with a transfer region **75** which disrupts the perimeter travel path **60** causing the food to enter the transfer region **75** and travel to the next adjacent tier **12** onto an adjacent (shown as underlying) perimeter travel path **60**. This time, the outermost perimeter travel path **60** can be the first one the food follows on this tier **12**. That is, the food may be forced to alter the sequence of travel on the perimeter paths **59, 60,** tier to tier, so as to travel inner to outer and then outer to inner as it progresses down (or up) the tiers in the processor **10**.

Figure 2 also illustrates that the transfer regions **75** may be circumferentially spaced or offset on each tier level so that the food transfers only a desired distance to the next underlying adjacent tier. In addition, the transfer regions can be formed into alternating inner and outer travel paths **59** to **60** tier to tier. The transfer regions **75** may be defined as open spaces which allow the food to drop (via gravity) down to the next level or as shoots, conveyors or other transfer means.

Certain portions, or all of, the product support surface of the travel pathway **25** can be defined by moving floors that propel, advance, or move the food substantially continuously along its travel path to treat the product in the food processor **10**. Each tier **11-14** can comprise one or more conveyors and/or moving floors (such as two or more side-by-side cooperating conveyors) to define the respective travel path. The conveyors can “cooperate” in that they can be configured to operate together to either hand off or receive food from the other conveyor so that the food serially travels first one then the other, as shown from either the inner perimeter path **59** to the outer **60,** or vice versa. For circular, oval, elliptical, or other endless and/or continuously moving configurations, the moving floor(s) may generate complex air or gas flow patterns that attempt to force (such as via centrifugal forces) the internal volume of gas or air to approach the wall of the processor **10**. Certain embodiments of the present invention are directed at providing fluid distribution systems and/or forced treated gas and/or

gas mixture flow patterns that can provide sufficient thermal or desired treatment exposure to the products as they move through the processor.

Figure 3 is a top view of a portion of a food travel path **25** held between sidewalls **10w$_1$**, **10w$_2$** forming part of the enclosure or housing of a food processor **10** (shown without the ceiling or top portion for clarity). **Figure 4A** illustrates one embodiment of an arrangement of inlet ports **40** and exhaust ports **50**. The system is configured to distribute one or more desired fluid treatments to the food in the processor. The term "air" may be used instead of the term "fluid" for ease of description in certain places in the text. However, use of this term is not to be interpreted as limiting the fluid distributed by the system to air. The system can be configured to distribute either fluids and/or gases such as gas mixtures that comprise different gases, gas(es) mixed with liquid, aerosols, and/or solid particulates or powder. The fluid or gas mixtures may be in a natural or untreated form or may be physically or chemically treated, modified, or altered or otherwise processed. The gas or gas mixture can be moisturized or treated with chemicals as desired to treat the food as desired as is known to those of skill in the art.

In particular embodiments, the fluid that is used to administer the treatment in at least one zone in the processor is formulated to comprise gas, and typically, air, as a major constituent. The gas or air may be thermally treated (cooled or heated) as desired.

As shown in **Figure 4A**, the inlet ports **40** are arranged about a common side of the travel path **25** while the exhaust ports **50** are also arranged about a common side of the food path, across or opposing the side with the inlet ports **40**. In the description, the inlet ports will be primarily positioned along one side of the track **25** with the exhaust ports on the other. However, as shown in **Figure 14A**, in certain embodiments, a minor number of exhaust ports **50** may positioned on the same side as the inlet ports **40** (or vice versa) as the primary direction of fluid cross-flow is not destroyed by the inclusion of these ports.

For brevity of description, as the embodiments are described with respect to fluid (typically gas or gas mixture) distribution systems herein, it is noted that, for each embodiment, the reverse arrangement can be used: that is, the exhaust ports and inlet ports, primary and secondary ducts, or combinations of same can be reversed as to location with respect to the side of the processor or track in which it is shown.

In operation, the inlet ports are supplied with unprocessed or processed exogenous fluid, generally comprising a gas or gases as a major constituent thereof (introduced under pressure such as with a blower, compressor or the like). Typically, the gas comprises air that may be thermally processed air, either heated or cooled in at least some portion of the processor **10** from an external exogenous supply source. As such, the inlet ports **40** are in fluid communication with the exogenous supply source of fluid such as thermally treated air.

As shown in **Figure 4A**, the inlet ports **40** may be spaced apart and be present about each or selected tiers **11-14** in a greater number than the number of exhaust ports **50**. In addition, as shown, the exhaust ports **50** may have a larger cross-sectional area than that of the inlet ports **40**. In certain embodiments, the cumulative cross-sectional area of the exhaust ports **50** can be substantially equal to or greater than the cumulative cross-sectional area of the inlet ports **40** while the number of inlet ports is greater than the number of exhaust ports **50**. This can, in certain configurations, promote a decreased pressure (approaching a vacuum) condition within the enclosure or food processor housing.

Alternatively, the cumulative cross-sectional area of the inlet ports **40** can be greater than that of the exhaust ports **50**. Such a system may create increased pressures in the enclosure of the processor **10**. In certain embodiments, one or more pressure relief valves or bleed valves (not shown) can be used to automatically discharge air from the processor **10** when the presence of a certain pressure level is detected or reached. Such a pressure-relief system can help to maintain the pressure at a desired level in one or more zones or tiers.

Figure 4B illustrates that the processor **10** can include a primary inlet duct **40d** and a primary exhaust duct **50d**. In the embodiment shown in **Figure 4B**, the primary inlet duct **40d** is positioned on a different side of the food path **25** than the primary exhaust duct **50d**. Other embodiments are shown in **Figures 11A, 11B, 12A-12D,** and **13A-13D** and will be discussed further below.

Referring again to **Figure 4B**, the primary exhaust duct **40d** can be positioned so as to be proximate the first sidewall **10w**$_1$ and/or intermediate the first sidewall **10w**$_1$ and track **25**. As shown, the duct **40d** is positioned to the inside of the enclosure or wall **10w**$_1$. In other embodiments, the duct **40d** may be positioned on the outside of the enclosure wall **10w**$_1$ and secondary ducts (**140d**, **Figure 5**) with a laterally

extending arm can be used to position the air inlet ports **40** where desired. If the latter, the secondary ducts can be sealed to the wall **10w$_1$** so as to inhibit air leakage at the junctions thereof. Similarly, the exhaust duct **50d** can also be positioned within or externally of the wall **10w$_2$** or a secondary duct or ducts (**150d**, **Figure 5**) with a laterally extending arm **150a** can be used to directly discharge the exhaust into the environment external of the processor **10**.

Figure 4B illustrates that inlet ports **40** can be vertically located proximate each tier level **11-18** (and may also be horizontally spaced as shown in **Figure 4A**). Similarly, exhaust ports **50** can be located proximate each tier level **11-18** (and may also be horizontally spaced as shown in **Figure 4A**). An exemplary fluid or gas flow distribution pattern is shown by the broken lines extending between the inlet ports **40** and the exhaust ports **50**. As shown, the fluid such as gas and/or air **25A** moves across the product that is held on the track or path **25** at each level or tier. As is also shown by tiers **15-18**, the inlet ports **40** may be substantially vertically aligned with one or more of the opposing exhaust port(s) **50**. In other embodiments, the inlet ports **40** may be located at a different vertical height at a particular tier relative to the height of the exhaust port or ports (measured from the center of the port).

Figure 4A illustrates that a number of aligned substantially equally spaced inlet ports **40** may be arranged about the first perimeter portion of the path or track **25** and a number of equally spaced aligned exhaust ports **50** (having greater spaced apart distances) may be arranged about the second opposing perimeter portion of the track **25**. In certain embodiments, non-equally spaced and/or horizontally or laterally offset ports (inlet and/or exhaust **40, 50**) may also be employed. Combinations of aligned and misaligned ports, either inlet **40** and/or exhaust **50** may also be used about a particular or selected tiers.

Figure 5 illustrates a food processor **10** having a substantially circular track **25** for one or more tiers. As such, the opposing sidewalls **10w$_1$**, **10w$_2$** are defined by the outer perimeter wall **10p$_1$** and the inner perimeter wall **10p$_2$**. The inlet ports **40** are dispersed about the distance of the outermost perimeter portion of the track **25**. In contrast, the exhaust ports **50** are positioned at discrete positions along the innermost perimeter portion of the track **25**. Additional numbers of exhaust ports **50** can also be used as indicated by the broken line circles in **Figure 5**. As shown, the track **25** can include two or more side-by-side lanes **59, 60** as desired. Further, as described above,

primary ducts (**40d**, **50d**, **Figure 4B**) and/or secondary ducts **140d**, **150d** may be used to introduce or discharge the air from the processor **10**.

Figure 6A illustrates an exemplary distributed flow pattern **25a** that may be generated by the arrangement of the distribution system. As shown, the fluid, gas and/or air travels from the inlet ports **40** positioned about the outermost portion of the track **25**, over the track **25** (over the food on the track floor **25f** during operation), and into the exhaust or discharge ports **50** while the track (*i.e.*, the floor of the track) and food are moving (the moving floor is shown by the heavy line arrowheads overlaying the track **25**).

Although shown as a contiguous floor **25f**, in systems employing a plurality of stacked tiers, one or more of the tiers may comprise floors formed as segments or portions that are moving and portions that are stationary, and may employ one or more conveyors. In certain embodiments, the tiers are configured to substantially continuously move food along its desired travel path that may include multiple revolutions and/or multiple tiers during the thermal processing. The flow pattern may represent static conditions or conditions where the floor or product speed is small relative to the speed of the input and/or exhaust gas or air.

Figure 6B illustrates an alternative flow pattern **25a** where the speed of the moving floor **25f** is such that the flow of the fluid is influenced so that the gas/air moves across the track **25** in an upstream direction and exits at a location that is forward of the inlet location when the floor **25f** moves in a counterclockwise and/or forward direction. The reverse would be true where the floor **25f** moves in a clockwise or reverse direction.

Figure 7 illustrates a nested **100** configuration, where an outer processor **110** is configured to surround or encase at least one inner processor **210**. Each of the processors (which may comprise ovens) **110**, **210** can have separate enclosures and/or sidewalls or may share one of the sidewalls. That is, the central perimeter wall **$100p_2$** can define the inner wall **$100w_2$** of the outer oven **110** and the outer wall **$100w_1$** of the inner oven **210**. In certain embodiments, each of the processors **110**, **210** can be separately insulated and regulated for desired operating environments (to provide the desired physical treatments such as selected fluids or gas mixtures, moisture, humidity, air velocity, temperature, chemicals, additives, ingredients, and the like). In addition, each tier or zone (a plurality of selected tiers) can be configured to have an

individually controlled environment. In addition, or alternatively, as shown in **Figures 14A** and **14B**, portions of one or more tiers can also be segmented **11s** from other portions of the respective tier **11** so as to have its own controllable processing environment.

As shown in **Figure 7**, each processor **110, 210** includes its own series of dispersed inlet and outlet ports **40, 50**. As shown, the outer perimeter of each processor is hexagonal with the inner perimeter being circular. However, in other embodiments, circular, annular, rectangular, oval, square or other desired shapes can also be used. *See* U.S. Patent Application Serial No. 09/888, 925 to Shefet et al. for additional description of nested ovens or processors, conveyor configurations, and tiers, the contents of which are hereby incorporated by reference as if recited in full herein.

Figure 8A is a schematic illustration of flow distribution about a plurality of tiers, the flow being represented by the arrows showing the fluid, typically gas, such as air, distributed and primarily moving in a direction that takes it across the product on each tier (traveling from an inner portion to an outer portion of the processor over the track **25** in each level or tier) as the product moves from the inlet **10i** to the outlet **10e** of the processor **10**. **Figure 8B** illustrates the reverse configuration with the gas, such as air, distributed and primarily moving in a direction that takes it across the product on each tier (traveling from an outer portion to an inner portion of the processor over the track **25** in each level or tier) as the product moves from the inlet **10i** to the outlet **10e** of the processor **10**

Figure 9A is a section view taken along the lines shown in **Figure 8A** and **8B** (although the flow direction indicated by the arrows corresponds to the embodiment shown in **Figure 8A**) and illustrates that, in certain embodiments, the track **25** in one or more tiers can define multiple side-by-side lanes $\mathbf{175_1}$, $\mathbf{175_2}$, $\mathbf{175_3}$, $\mathbf{175_4}$, $\mathbf{175_5}$, $\mathbf{175_6}$ of food **125** traffic. The thermally processed air **25a** is directed to travel between each tier and across the food **125** located in each lane $\mathbf{175_1}$**-175n**.

Figure 9B is a section view similar to **Figure 9A**, but illustrates a different multi-track configuration from that shown in **Figure 9A**. As shown, in certain embodiments, the track **25** in one or more tiers can define multiple side-by-side lanes $\mathbf{175_1}$, $\mathbf{175_2}$, $\mathbf{175_3}$, $\mathbf{175_4}$, $\mathbf{175_5}$, $\mathbf{175_6}$ of food **125** traffic with a gap space **25g** between floor support members (such as spaced apart rods) that provide the track. The

thermally processed air **25a** is again directed to travel between each tier and across the food **125** located in each lane **175_1-175n**. Descriptions of additional gap-spaced flooring is described in co-pending U.S. Provisional Patent Application filed February 4, 2002, identified by Attorney Docket No. 9281-3PR, the contents of which are hereby incorporated by reference as if recited in full herein.

Figure 10 is a schematic illustration of a perspective view of a portion of a processor according to certain embodiments of the present invention. As shown, at least one upwardly extending primary inlet duct **140d** is positioned about a first side of the track **25** in each tier **11-14**. Various configurations of secondary ducts **140d** may be used to position the ports **40** as desired while providing the fluid communication with the exogenous supply of fluid, air or gas that is to be introduced via the inlet ports **40**. For example, tier **11** illustrates a first embodiment where inlet ports **40** are positioned at vertical heights that are both above and below the track **25,** all via secondary ducting **140d** that extends from the primary duct **40**. Tier **12** illustrates a plurality of secondary ducts **140d'** with laterally extending portions can be used, each may have a different length and or size as desired, and all may be positioned about the same vertical height. Tier **13** illustrates that a manifold of ducts **140d''** can be used to distribute the fluid, gas, and/or air through inlet ports **40** as desired. Tier **14** is employs secondary ducts **140d'''** that are circumferentially dispersed about the track **25**.

Figure 10 also illustrates the use of at least one primary discharge duct **50d** and associated secondary ducting **150d** or port placement **50** that influences the fluid or gas distribution. Some of the discharge ducting is arranged so that ports **50** are located both above and below the track **25** as shown in tier **12**. In this manner, the discharge ports **50** may influence fluid or gas flow (receive discharged gas or air from) two or more adjacent tiers. The arrangement in tier **11** provides two vertically spaced apart locations for discharge ports **50**, one position being substantially level or just above the surface of the track **25** and another a distance above the track. Used with inlet ports **40** that are positioned lower than the track **25** may provide an increased distribution or increased gas or air flow or current over the food (as heated gas/air has a natural tendency to rise) or when used with lower tiers, may promote turbulent mixing of the gas/air resulting in better distribution and/or more uniform temperatures across the width of the track **25**. Exemplary portions of flow patterns

are shown in **Figure 10** about a portion of each tier **11-14**. Discharge manifolds **150d'** such as that shown for tier **11** or other ducting and/or manifold arrangements can also be used as desired for the application. Further, although the ports **40, 50** are illustrated as oriented to output/intake in the direction of the track, they may be turned to face away from the track as the pressure differential will still act to move the gas/air across the track.

Additional quantities of upwardly extending primary ducts **40d**, **50d** may also be used as desired to position the desired number of air inlet and exhaust ports **40, 50** in the desired locations about the track **25** as desired. They may be clustered together or spaced apart about the track **25**. In addition, certain regions, zones or tiers may be configured to be substantially enclosed, relative to the other adjacent spaces, so as to be able to independently provide different climates or processing conditions. As such, ceilings, floors, baffles, or the like may be positioned at certain locations within the processor **10** (not shown).

Figures 11A and **11B** illustrate yet another embodiment of a forced flow distribution system. As shown in **Figure 11B**, the primary exhaust and inlet ducts **50d, 40d**, respectively, are located on the same side of the track **25**. However, as shown in **Figure 11A**, the exhaust ports **50** are located on the same side of the track **25** as the primary ducts **40d, 50d**, and the inlet ports **40** are located on the opposing side thereof. This distribution can be provided in a number of ways. As shown in **Figure 11A**, a series of secondary ducts **140d** have arms that are in fluid communication with the primary duct **40d** and span the track **25** to position the ports **40** on the opposing side of the track **25** a lateral distance away from the primary duct **40d**. **Figure 11B** shows that the secondary ducts **140d** may include both a lateral segment **140L** and a vertical segment **140V** configured to position the inlet ports **40** proximate each tier **11-18**. A similar duct arrangement can be used to position the exhaust system in its desired locations.

As is also shown in **Figure 11A**, there are a greater number of spaced apart inlet ports **40** than the opposing exhaust ports **50**. In addition, the opening or cross-sectional area of the inlet ports are smaller than the exhaust ports **50**. As discussed above, in particular embodiments, the cumulative area of the exhaust ports in certain regions, tiers, or in the entire processor, is substantially equal to or greater than the corresponding cumulative cross-section or opening sizes of the inlet ports **40**. Also

shown in **Figure 11A**, all exhaust ports **50** and/or all inlet ports **40**, in a particular tier or zone, may be arranged to be substantially aligned so as to be located at the same vertical distance and equally spaced about a portion of the track (or the entire length of the tier) such that the inlet ports **40** are on one side of the track **25** (where the food resides and is moved during operation) and the outlet ports are on the other side of the track **25**.

Figures 12A-12D illustrate that, for each or selected tiers, the inlet ports **40** and exhaust ports **50** may be configured at the same or different vertical heights. **Figure 12A** illustrates that for each tier **11-14**, the inlet ports **40** and exhaust ports **50** are located at the substantially the same vertical location. **Figure 12B** illustrates that, for each tier **11-14**, the inlet ports **40** are located below the corresponding exhaust ports **50**. **Figure 12C** illustrates that the inlet ports are located at a lesser number of vertical heights relative to the exhaust ports, such as proximate ever other tier **12, 14**, while the exhaust ports may be located proximate to each tier **11-14**. **Figure 12D** illustrates that a single or centrally located array of inlet ports may be disposed in the processor with exhaust ports located proximate each tier **11-14**. As noted above, the position of the inlet ports **40** and exhaust ports **50** relative to the side of the track **25** they are illustrated on can be reversed.

Figures 13A-13D illustrate other ducting embodiments. As noted previously, the primary ducts **40d, 50d** may be positioned on the same side of the track **25**, or opposing sides of the track (either in or outside the walls of the oven). Thus, in certain embodiments, secondary ducts can be used to locate or position the ports **40, 50** in the desired locations about one or more tiers **11-14**. For clarity, the primary ducts in **Figures 13A-13D** have been labeled as the inlet ducts **40d, 140d**, but the same configurations can be used for the exhaust ducts **50d, 150d** to distribute the exhaust system. **Figure 13A** illustrates that each tier may employ a secondary laterally extending duct **140d**. **Figures 13B-13D** shows examples of secondary ducting that may be in fluid communication with the primary duct **40d**. That is, the ducting can include a secondary duct system **140d** that includes vertical and horizontal or lateral components, **140V, 140L** that can be configured in various manners to extend between above, or below selected tiers **11-14**. Various combinations of those shown as well as other configurations may also be employed.

Embodiments of the invention can provide a multi-zone (tier) processor with each zone having similar or different thermal gradients (the thermal gradient measured as temperature versus distance from a wall of the processor to an opposing wall and/or from a position proximate a first side of the track to the other side of the track across the food travel lane(s)). The thermal gradients may be such that the air temperature proximate the product across the width of the lane is substantially constant or uniform within a particular space so that food is relatively consistently exposed to a thermal treatment as it travels through a tier, segment of a tier, zone, and/or the entire processor.

Figure 14A illustrates a top view of one embodiment of a tier **11**. As shown, the tier **11** may include a segmented portion **11s** that is substantially physically isolated from the other portion of the same tier **11**. As shown by the hatched lines representing the ceiling **11c** in the top view of the segment **11s**, the segment **11s** can be partitioned from the other portion of the tier so that it's environment is separately individually controllable. **Figure 14B** illustrates that the segment **11s** includes upstanding walls **$11w_1$, $11w_2$, $11w_3$, $11w_4$** that, with the ceiling **11c**, substantially encloses the corresponding portion or length of track **25**. The forward portion of the wall **$11w_3$** can include two side components **$11w_{3a}$, $11w_{3b}$** with a gap space **11a** overlying the track **25** that allows the track (and/or food thereon) to move therein.

Figure 14A also illustrates that the present invention contemplates the use of exhaust ports **50** on the same side of the track as the inlet ports **40** and/or vice versa, inlet ports **40** on the same side as the outlet ports **50** (in segmented or non-segmented portions of the tier(s)). That is, a minor number of such opposite function ports positioned on the other side of the track from the corresponding major portion of like function, may be arranged and configured so as to not stop and/or unduly interfere with the desired cross-flow pattern of the fluid, gas and/or air in the processor and may be used in certain embodiments.

Figure 15 illustrates that the processor **10** may be configured with spaced apart tracks **25_1, 25_2**, (shown as two, but additional numbers of tracks can also be used) with at least one of inlet or outlet ports **40**, **50**, respectively, positioned intermediate thereof. As shown, a plurality of inlet ports **40** are circumferentially spaced apart about the space between the tracks **25_1, 25_2** and exhaust ports **50** are located both on the outer portion of the first track **25_1** and the inner portion of the

second track 25_2. The ports **40, 50** can be configured in reverse, with the exhaust ports located between the tracks $\mathbf{25_1}$, $\mathbf{25_2}$ and the inlet ports **40** located both on the outer portion of the first track $\mathbf{25_1}$ and the inner portion of the second track $\mathbf{25_2}$. Portions of either or both of the first or second track $\mathbf{25_1}$, $\mathbf{25_2}$ may be segmented as described for **Figures 14A** and **14B.**

Referring to **Figures 2** and **6A**, where used, the speed of the conveyor(s) used to form one or more of the moving floors for the travel lanes **59**, **60** forming the track **25** including those described above, can be set to match the desired residence time according to the time desired in each tier. In certain embodiments, the oven can be configured with a height of between about 20-40 feet with a length of between about 60-400 feet and a width of between about 20-100 feet running an elongated meat product at about 5-6.5fps (feet per second). Of course, the processors or ovens of the present invention are not limited thereto, as any desired profile (height x width x depth) can be used depending on the floor space and ceiling limitations and the capacity or processing (time) requirements. In certain embodiments, the food processor **10** can include one or more zones that form an oven and can be configured to throughput at least about 5,000-23,000 feet per hour of a food item, typically an elongated meat product, during a desired period.

The conveyors on each tier or between tiers can be operated or adjusted so as to run at the same or different conveyor speeds. In certain embodiments, the processor **10** can be configured to concurrently process a plurality of elongated strands (such as, but not limited to, about 4-50 strands). In certain embodiments, about seven to fourteen separate strands of elongated continuous food product can be introduced into the food inlet and onto the upper tier. In so doing, the surface of the lanes **11** can include holding grooves or guides to help position the strands side-by-side on the respective travel paths in each tier. As such, each travel lane shown in **Figures 2, 5, 8, 9A, 9B, 14, 14** can hold a discrete strand of food product or the strand may have a length such that it covers more than one lane during processing which travel concurrently serially about each of the lanes to make the desired number of revolutions at each tier.

In certain embodiments, the processor **10** can be configured with a plurality of vertically stacked layers and an elongated meat product or strand can be directed to travel serially over each of the layers at a desired rate. For example, for food dwelling

at about 1 minute per layer, and a 60-layer configuration, the food will have a cumulative processor dwelling time of about 1 hour.

In certain embodiments, the processor can be configured to throughput of at least about 5,000-23,000 feet per hour of a food item, typically an elongated meat product.

In certain embodiments, one or a plurality of separate strands of elongated continuous food product can be introduced into the food inlet and onto the upper tier. In so doing, the lanes shown as two perimeter paths **59**, **60** in **Figure 2**, can include holding grooves or guides to help position the strands side-by-side on the respective travel paths in each tier. In addition, a plurality of food diverters can be positioned in the transfer zone **50z** to divert the strands to the other adjacent travel path. As such, each single food line or travel path shown in **Figures 1-15** can represent a plurality of side-by-side products, which travel concurrently serially about each of the perimeter paths to make the desired number of revolutions at each tier.

It is noted that the present invention also contemplates that single tier embodiments can also be employed and/or stacked tiers **10** can be configured as any suitable or desired combinations of the tier configurations, the conveyor configurations and/or travel paths described herein.

The travel pathway may include channels, grooves, or other configurations that are configured to hold food thereon. The travel pathway be configured as substantially planar, or non-planar, they may be substantially open support surfaces or enclosed (partially, or totally) channels, the food may be processed as it directly resides on the floor of the travel pathway or the food may be packaged or put into transportable containers. The present invention contemplates that any number of suitable travel pathways, support configurations, and/or advancing mechanisms can be used to carry out operations associated with the present invention.

In certain embodiments, a container can be used to hold the food therein during its progression through the processor. For example, an elongated food snack item that can be introduced in a liquid or gelatinous form (yogurt, freezable edible confections) and processed in a container (a flexible package or closed or open rigid container). The product may be processed so as to be frozen as a result of its travel in the processor. The packaging or containers may be strung or attached together in desired lengths.

The forced air systems can be used with any desired processing system, including any desired heating or cooking configuration such as, but not limited to, RF, microwave, light energy (infrared, solar and the like), irradiation, and the like.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. In the claims, means-plus-function clauses, where used, are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the appended claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.